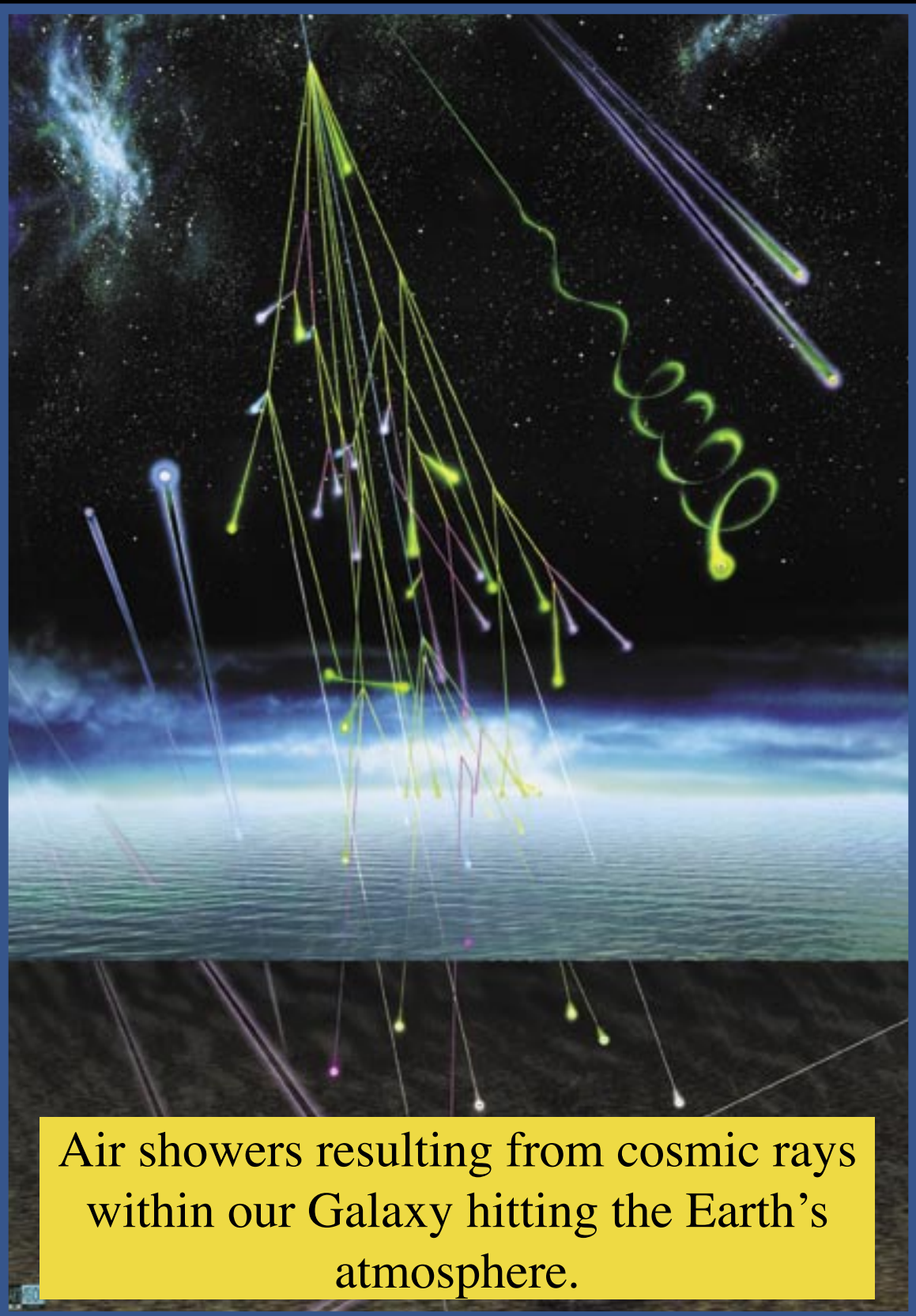


Off the Scale?



Air showers resulting from cosmic rays within our Galaxy hitting the Earth's atmosphere.

Not everything in space can be measured by electromagnetic energy. Particles and gravitational waves give us different information about objects and events in the Universe.

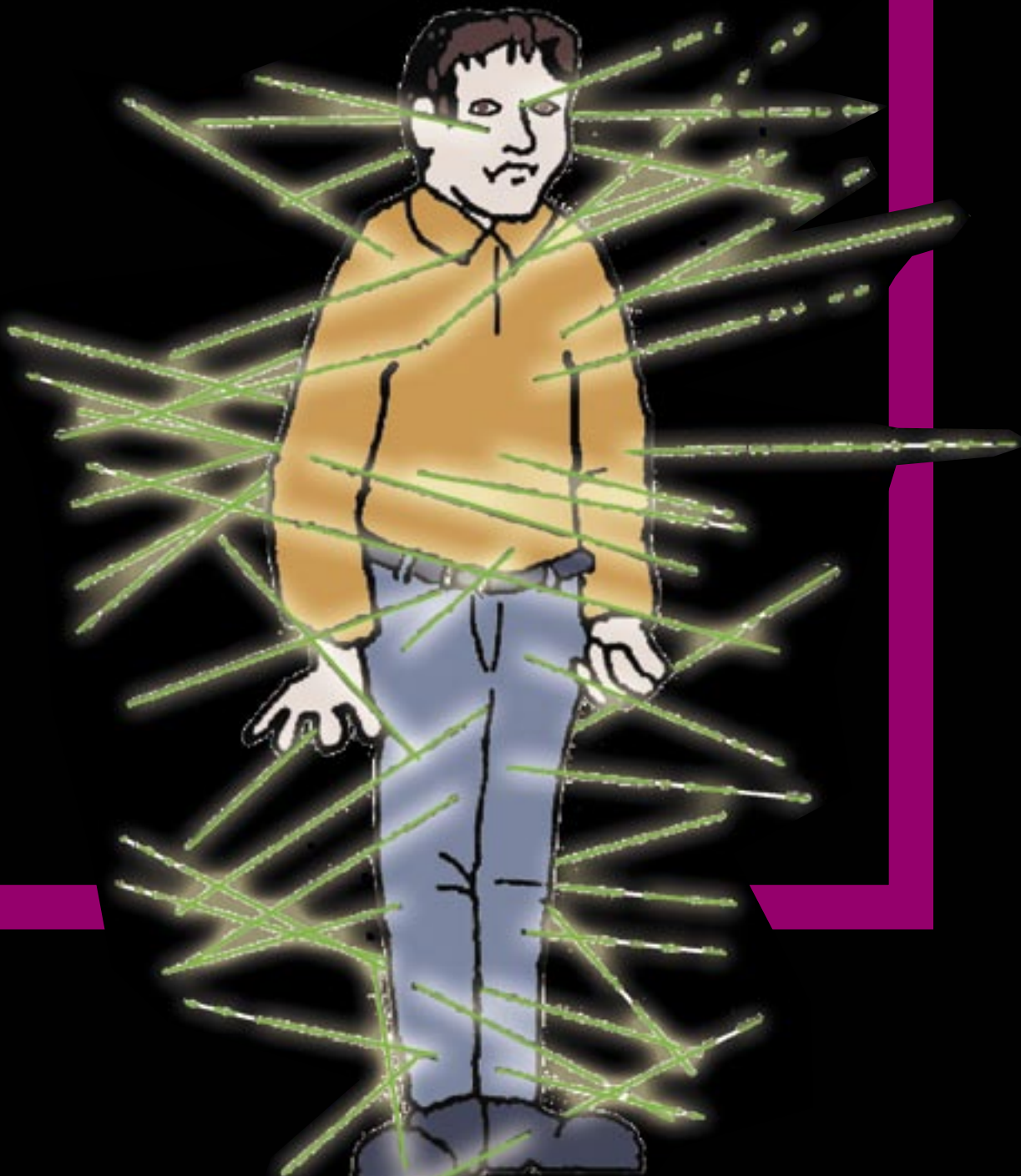
Cosmic rays are not rays but pieces of atoms from space that continuously rain down on the Earth at near light speed. They are one of the very few samples of matter we have from outside of our Solar System. These particles arrive from the farthest reaches of our Galaxy and from as close as the Sun.

We can't make maps of cosmic-ray sources in the sky as we can for sources of light, like stars. Magnetic fields from stars and planets bounce and hurl them around along their

journey to Earth, so we can't determine their point of origin. But we can learn about a cosmic-ray particle's history by using scientific instruments to determine which element (and which isotope of that element) it is.

COOL FACT

Some cosmic rays have so much energy that scientists cannot explain their existence. These ultrahigh-energy cosmic rays (UHECR) may come from outside the Galaxy, or they may represent some exotic new physics!



100,000 cosmic rays will hit you in the next hour!

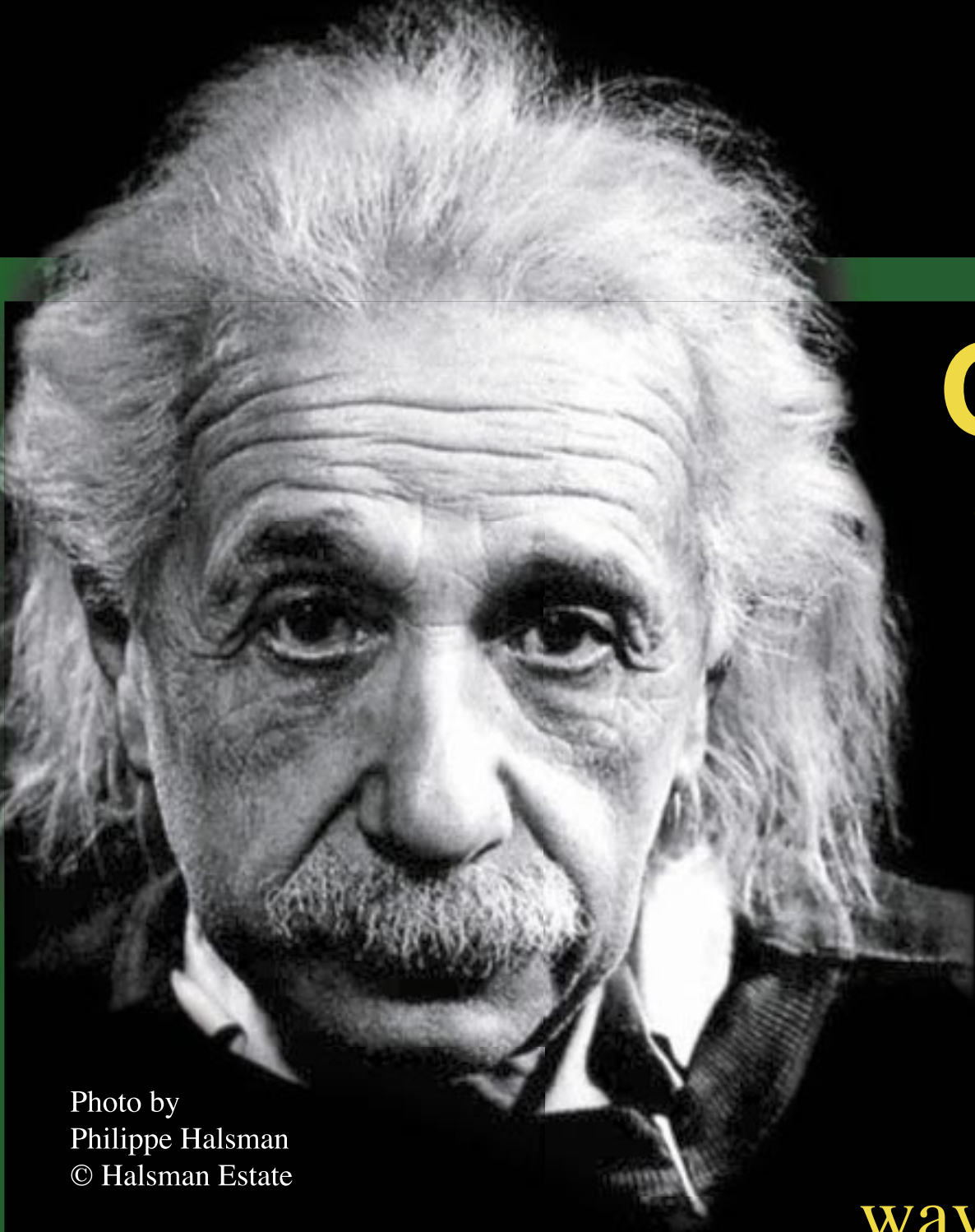


Photo by
Philippe Halsman
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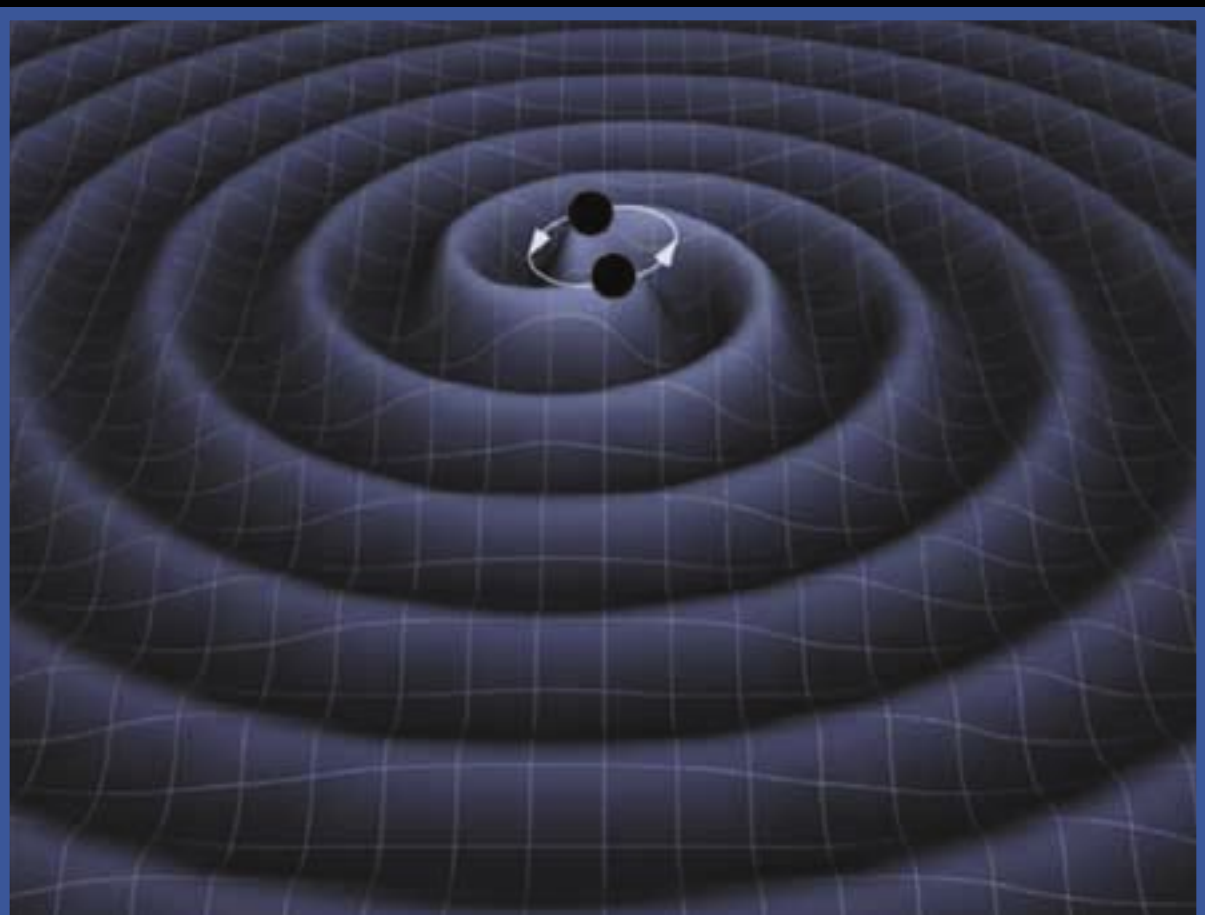
Gravitational waves are created by the fast movement of massive objects such as black holes or binary stars. This rapid motion releases gravitational energy, sending ripples out from the objects like a stone tossed into a lake. The gravitational waves spread across space, bending it up and down.

The biggest gravitational waves are caused by huge events, such as the merger of two gigantic stars orbiting each other, a massive star orbiting a black hole, or even two black holes orbiting each other. But the waves from even these events are very weak by the time they reach us from so far away.

Einstein's Theory of General Relativity predicts these waves, but they are very hard to detect. Currently, astronomers cannot measure them directly, but can observe their effect on the bodies emitting them: we see closely orbiting neutron stars gradually spiralling in toward each other.

COOL FACT

It is thought that energy is released at a faster rate in the brief burst of gravitational waves from a black hole collision than in any other known event!



Neutron stars gradually spiralling together produce "ripples" in the curvature of space-time.

Goddard's Laboratory for High Energy Astrophysics supports several cosmic ray missions: ACE (Advanced Composition Explorer), Wind/EPACT (Energetic Particle Acceleration, Composition, and Transport), and the TIGER (Trans-Iron Galactic Element Recorder) balloon mission. The NIGHTGLOW balloon mission collects data in preparation for a future UHECR mission. The Lab also supports the development of LISA (Laser Interferometer Space Antenna), a future gravitational-wave mission.